REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave Blank)*

2. REPORT DATE
08/00/83

3. REPORT TYPE AND DATES COVERED
NONE

4. TITLE AND SUBTITLE
RESULTS OF DOUBLE RING INFILTROMETER INVESTIGATIONS, ROCKY MOUNTAIN ARSENAL, JULY 13-15, 1983

5. FUNDING NUMBERS
NONE

6. AUTHOR(S)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
RESOURCE CONSULTANTS

8. PERFORMING ORGANIZATION REPORT NUMBER
83235R01

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSERING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
NONE

12a. DISTRIBUTION/AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

THIS INVESTIGATION WAS THE RESULT OF THE CONTINUED INTEREST IN INFILTRATION POTENTIAL IN CERTAIN PORTIONS OF THE RMA. PREVIOUS ESTIMATES OF INFILTRATION WERE BASED ON DATA PRESENTED IN SOIL SURVEY OF ADAMS COUNTY, CO (USDA SOIL CONSERVATION SERVICE AND COLORADO AG EXPERIMENT STATION, 1974). IN ORDER TO OBTAIN MORE SITE-SPECIFIC DATA, TEN SITES WERE SELECTED BY RMA PERSONNEL WHERE DOUBLE-RING INFILTROMETERS WOULD BE INSTALLED AND THEN LEFT IN PLACE. THESE SITES ARE IN THE SOUTH PLANTS AREA AND IN BASIN A.

14. SUBJECT TERMS
BASIN A, SOUTH PLANTS, SOIL, GROUNDWATER

15. NUMBER OF PAGES
17

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT
UNCLASSIFIED

18. SECURITY CLASSIFICATION OF THIS PAGE

19. SECURITY CLASSIFICATION OF ABSTRACT

20. LIMITATION OF ABSTRACT

Box C

83235R01
extra

RESOURCE
CONSULTANTS INC

TABLE OF CONTENTS

TABLE

FIGURES

RESULTS OF DOUBLE RING INFILTROMETER INVESTIGATIONS ROCKY MOUNTAIN ARSENAL JULY 13-15, 1983

Introduction

This investigation was the result of the continued interest in infiltration potential in certain portions of the Rocky Mountain Arsenal. Previous estimates of infiltration were based on data presented in Soil Survey of Adams County, Colorado (USDA Soil Conservation Service & Colo. Ag. Exper. Station, 1974). In order to obtain more site-specific data, ten sites were selected by Rocky Mountain Arsenal personnel where double-ring infiltrometers would be installed and then left in place. These sites are in the South Plants Area and in Basin A. Fig. 1 shows the location of all ten sites.

Infiltration is defined as the movement of water into the soil matrix from the surface of the soil. It is normally expressed as a rate (f), e.g., centimeters per hour, etc. Various factors will influence the rate, such as the soil type, vegetal cover, rate of rainfall (or the rate at which water is available to enter the soil), chemical properties of the soil and the water, etc. It is also important to note that infiltration will vary with time. On a dry soil the initial infiltration rate may be several times the final or equilibrium rate.

The basic equation governing infiltration is that developed by Horton (1935) which resulted from his work during the early 1930's. This relationship is:

$$f = f_c + (f_o - f_c)\, e^{-kt}$$

where

f = infiltration rate (depth/time) at time t
k = a constant for the decrease in f
f_c = final or equilibrium value of f
f_o = initial infiltration rate

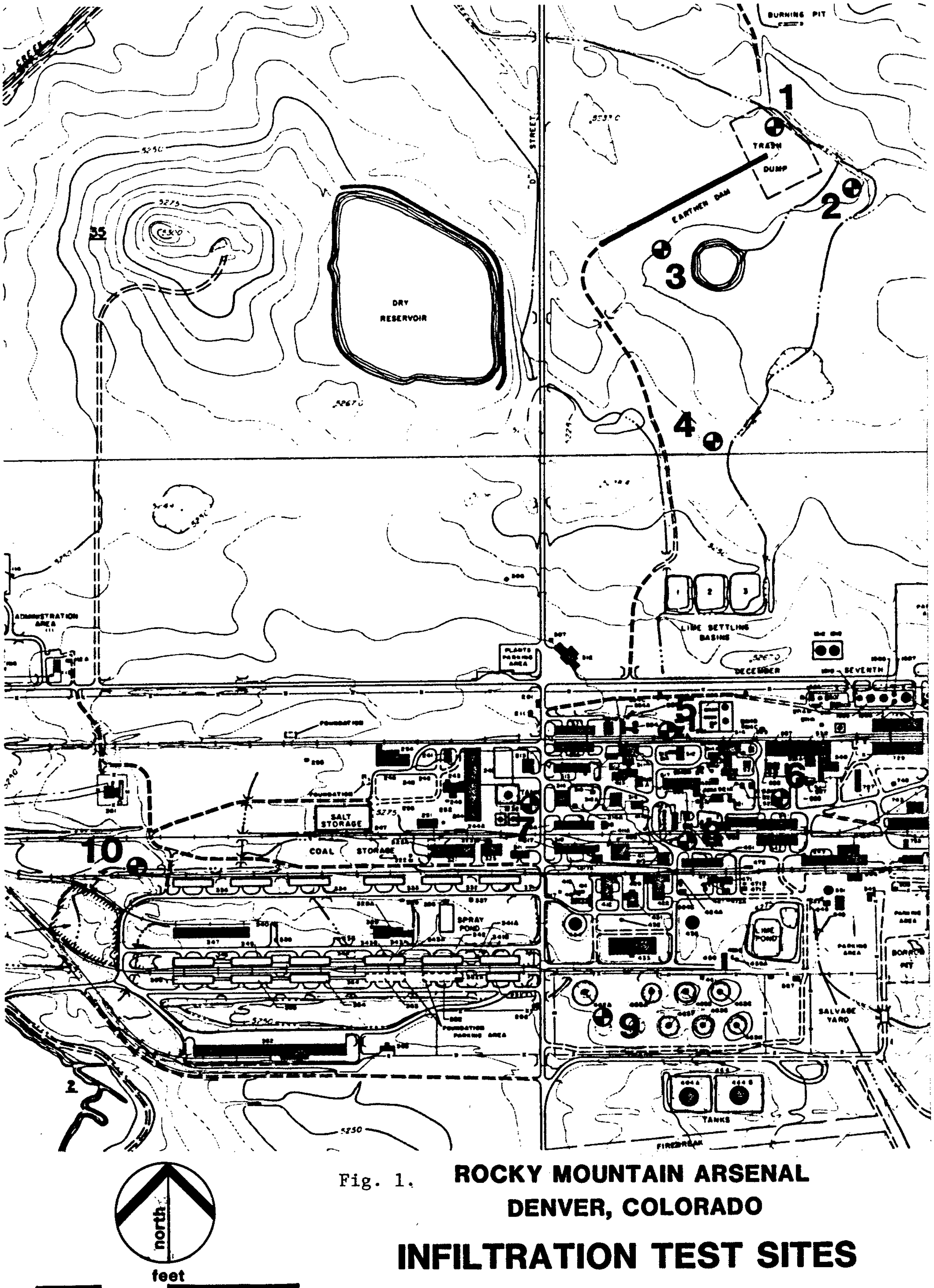


Fig. 1. **ROCKY MOUNTAIN ARSENAL DENVER, COLORADO**

INFILTRATION TEST SITES

RESOURCE CONSULTANTS, INC. – FORT COLLINS, COLORADO

A dual ring infiltrometer was used for these investigations at the Rocky Mountain Arsenal. The procedures for this method are set forth in ASTM Procedure Number D 3385-75 (American Society for Testing and Materials, 1978). The procedure is also discussed by Johnson (1963) in U. S. Geological Survey Water-Supply Paper No. 1544-F.

The dual rings of the infiltrometer were constructed of 10-gauge metal. The inner ring has an inside diameter of 12 inches and the outside ring has an inside diameter of 18 inches. Both rings are 12 inches deep. The inside ring was driven into the soil matrix a depth of 2 inches and the outside ring was driven to a depth of 5 inches. Inside the inner ring and between the two rings a small diameter metal rod, sharpened at the tip, was used as a reference point so the water would be kept at the desired level of 3 inches. Figures 2 through 5 show a typical installation.

Results Obtained

Fig. 1 shows the locations of the two sites selected. A detailed description of each site is included in Appendix A. Figures 6 through 15 show the graphical determination of the infiltration rates over time. It is important to note that the tests conducted were under a "dry soil" condition. Complete numerical data for these ten sites are shown in Appendix B and the f_c values are shown in Table 1.

Table 1
Values of "f_c" for Each of the Ten Sites

Site	f_c 1/ (cm/hr)
1	0.03
2	0.04
3	0.03
4	Data not meaningful
5	0.23
6	2.55
7	0.74
8	1.03
9	1.93
10	5.21

1/ Values were determined graphically from Figures 6 through 16.

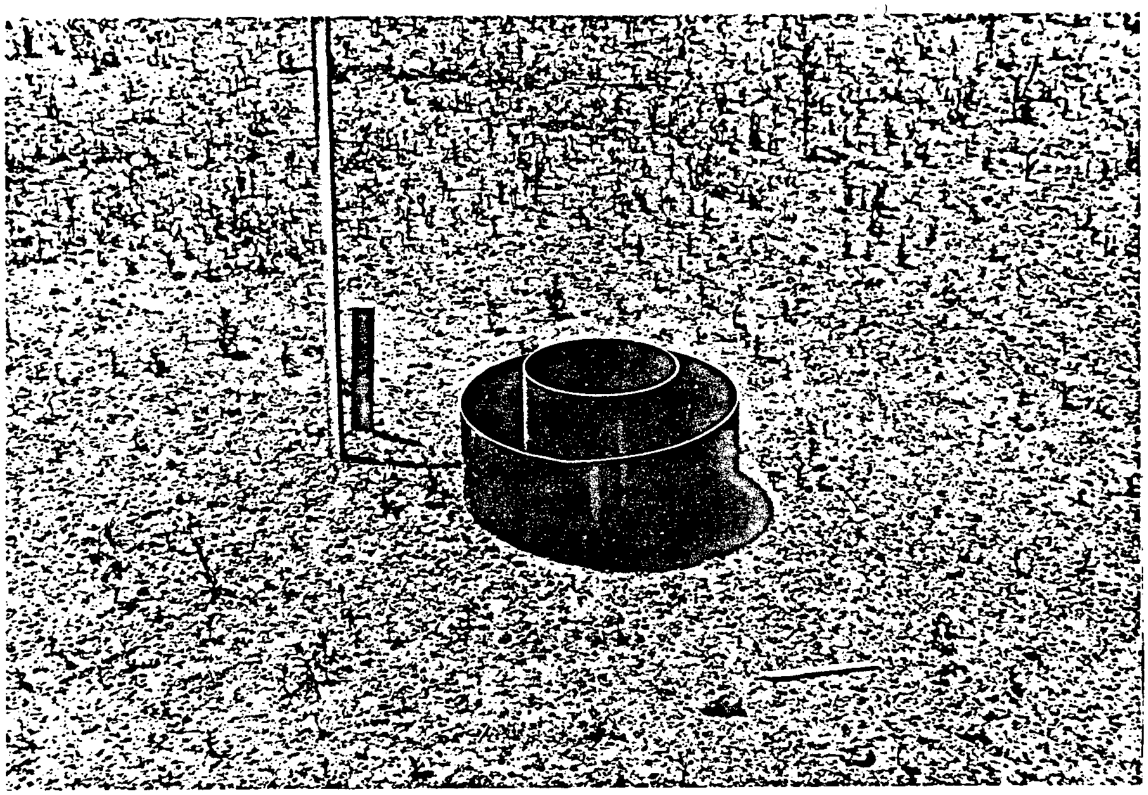


Fig. 2. Typical View of Double Ring Infiltrometer

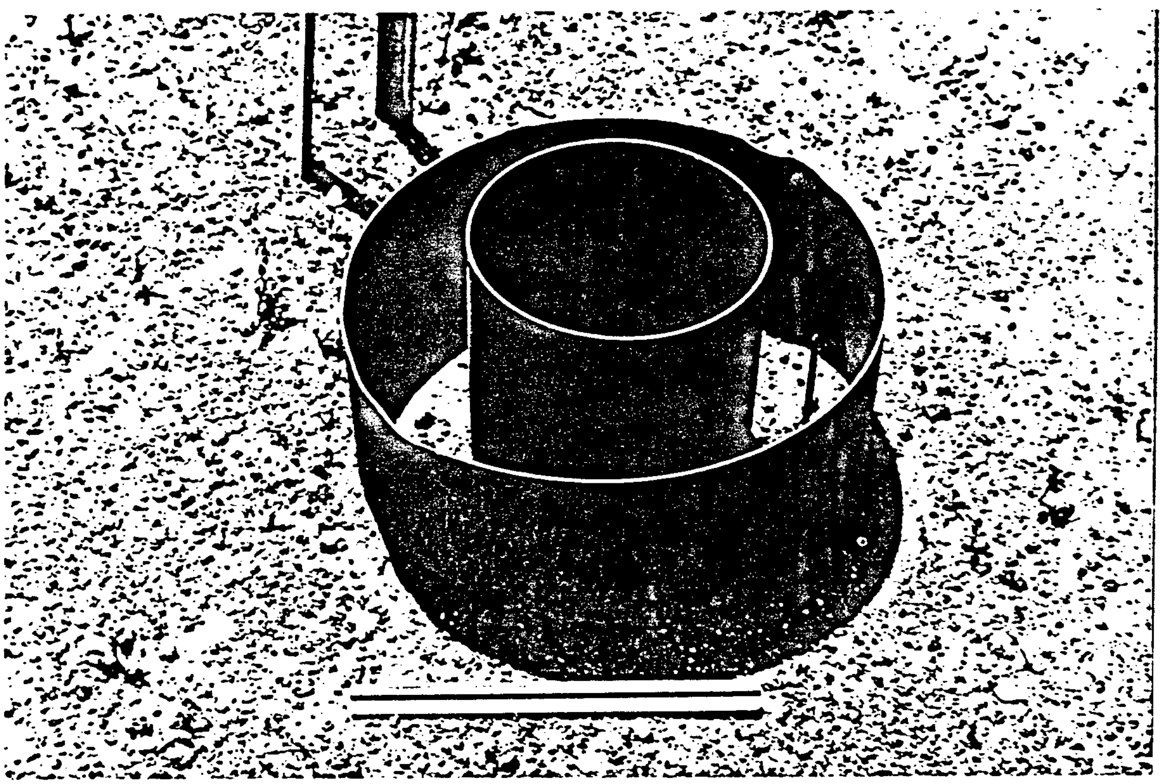


Fig. 3. Typical View of Double Ring Infiltrometer

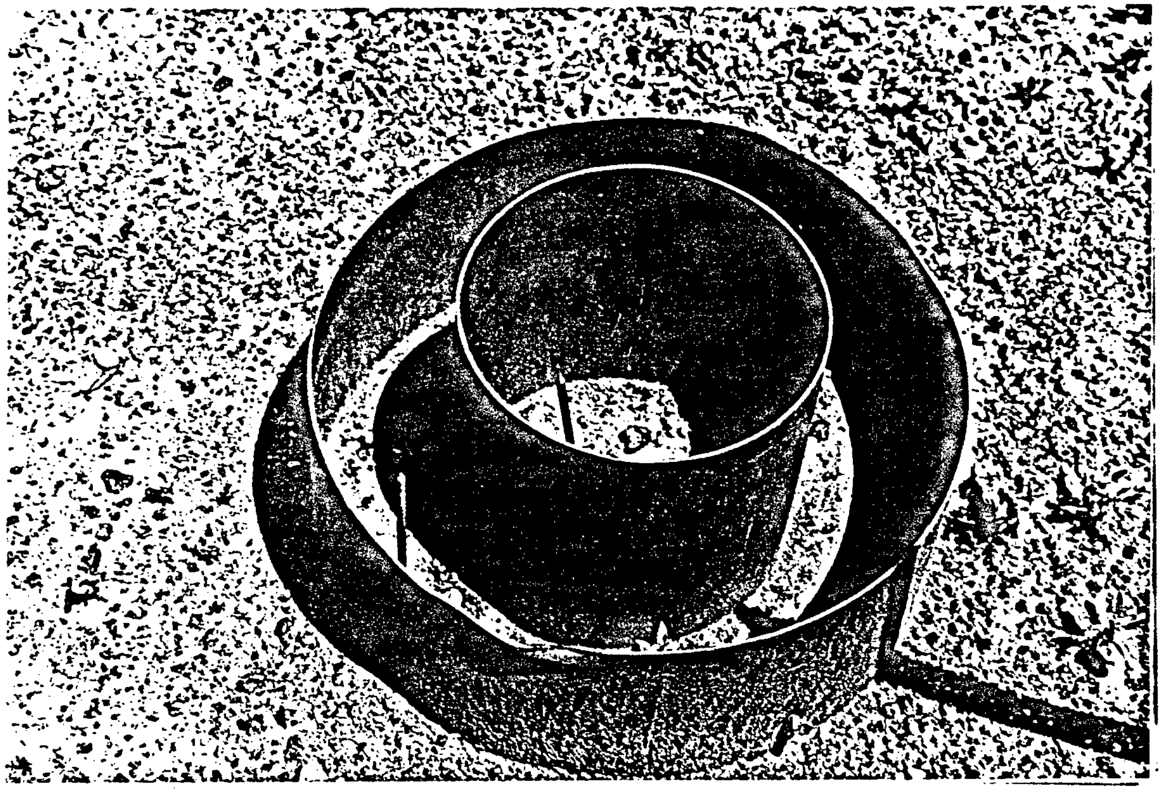


Fig. 4. Typical View of Double Ring Infiltrometer

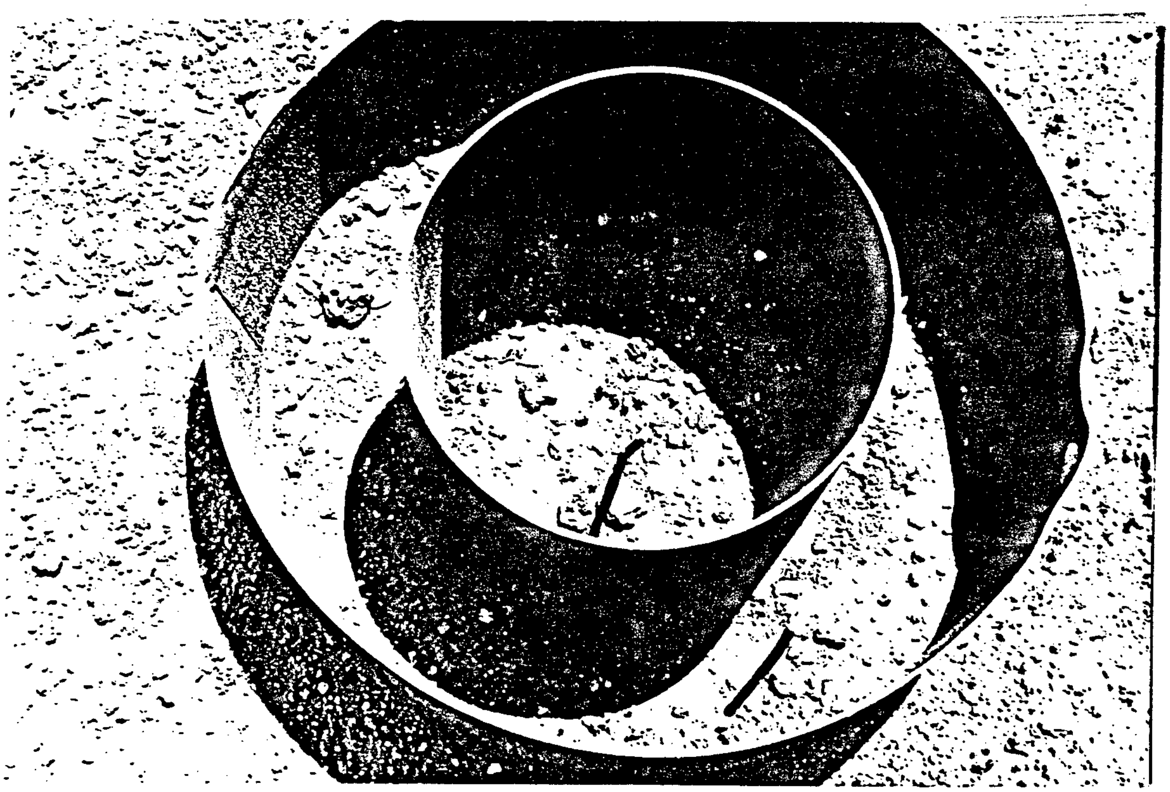
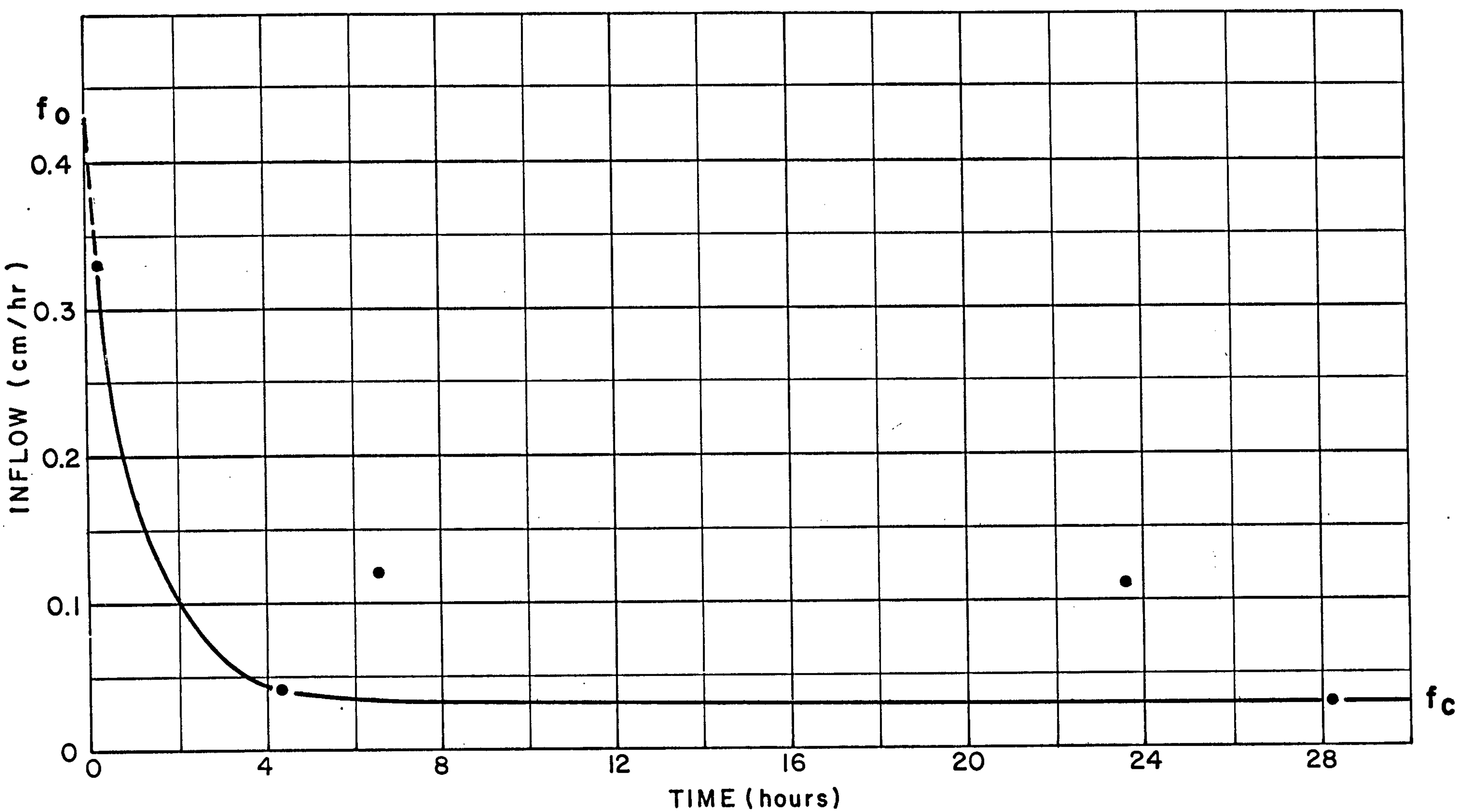
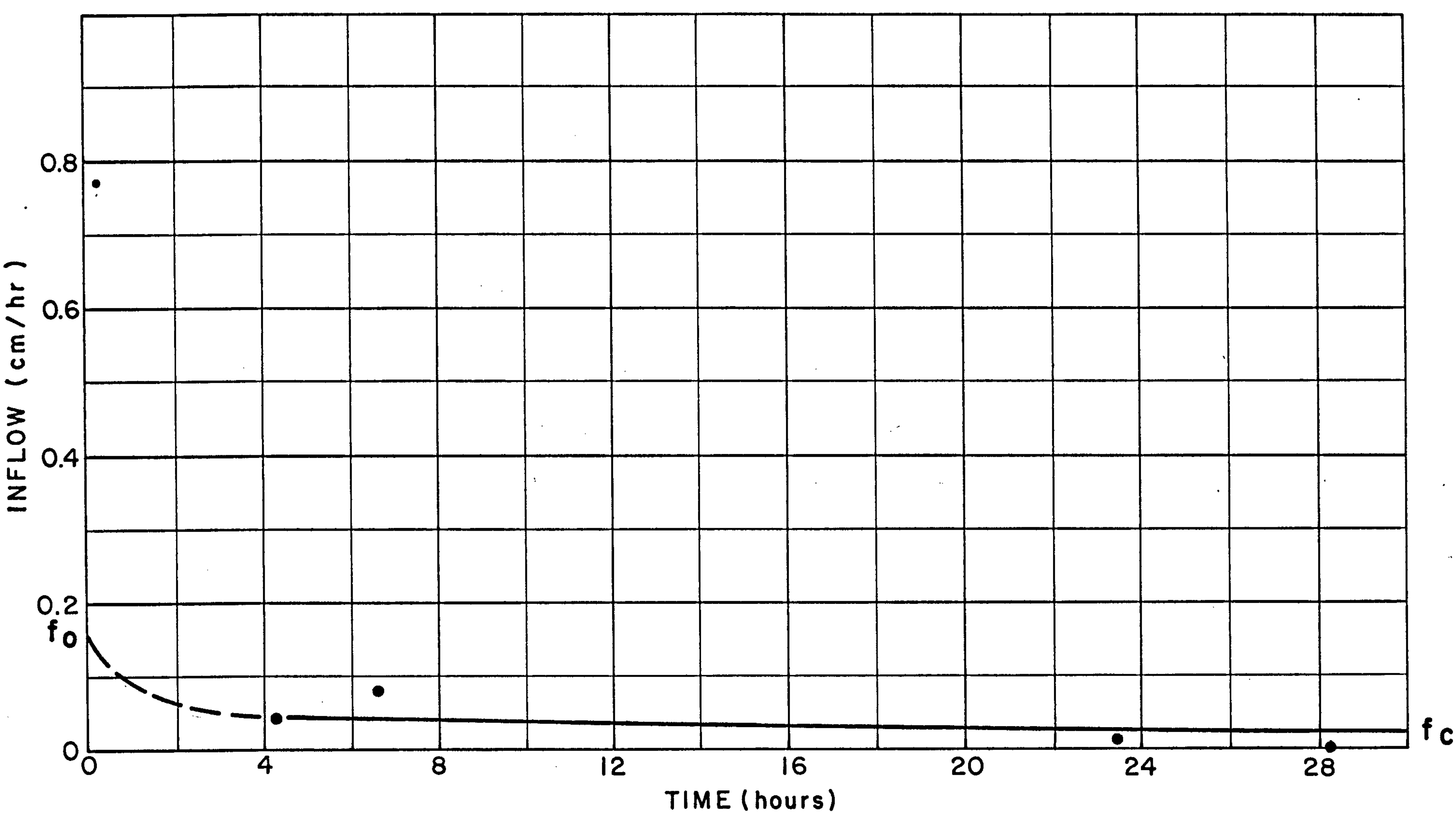


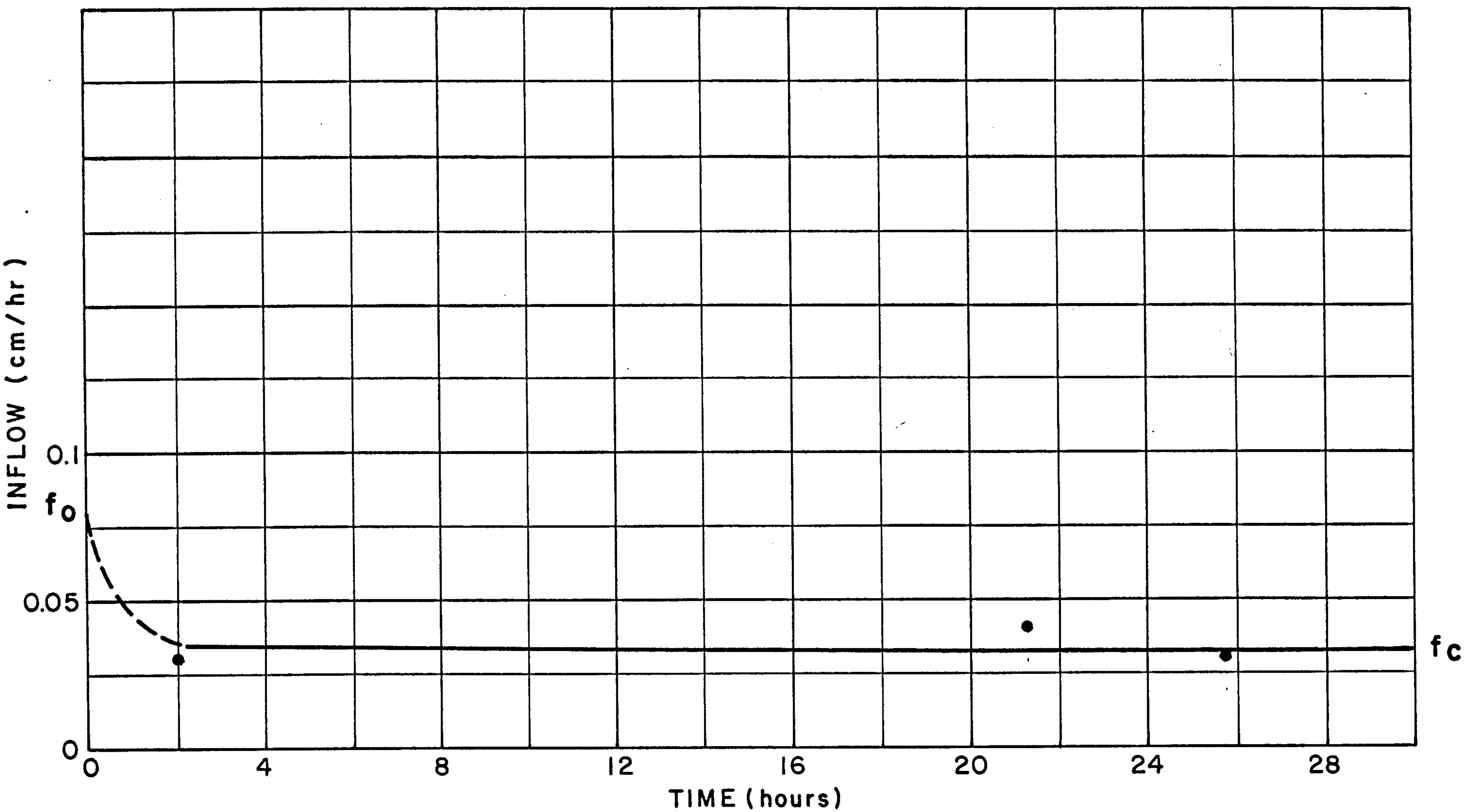
Fig. 5. Typical View of Double Ring Infiltrometer



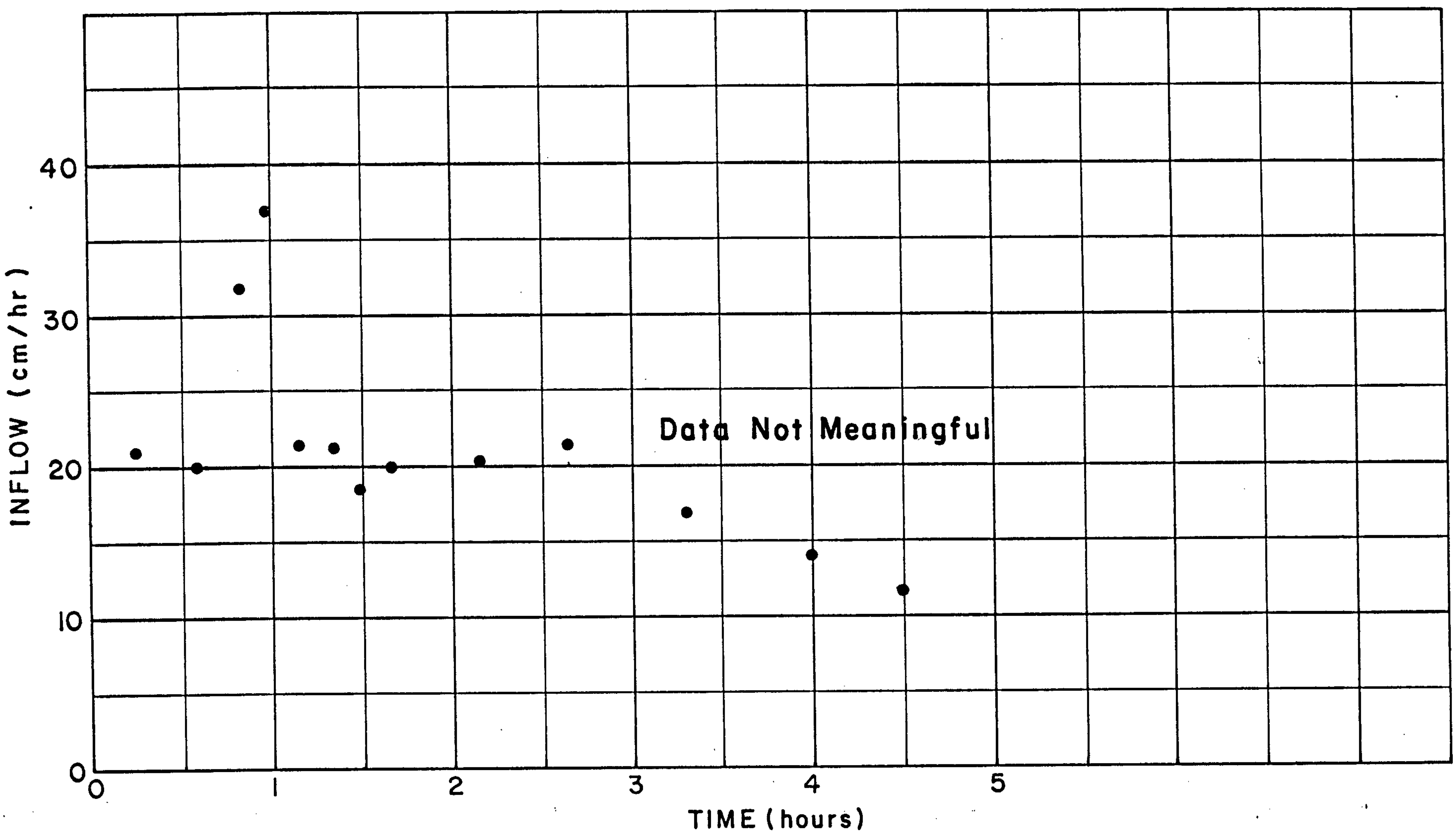
ROCKY MOUNTAIN ARSENAL DENVER, COLORADO RESOURCE CONSULTANTS, INC. - FORT COLLINS, COLORADO	Fig. 6. **INFILTRATION SITE No. 1**	7/14/83 7/15/83



ROCKY MOUNTAIN ARSENAL **DENVER, COLORADO** RESOURCE CONSULTANTS, INC. – FORT COLLINS, COLORADO	Fig. 7. **INFILTRATION SITE No. 2**	**7/14/83** **7/15/83**



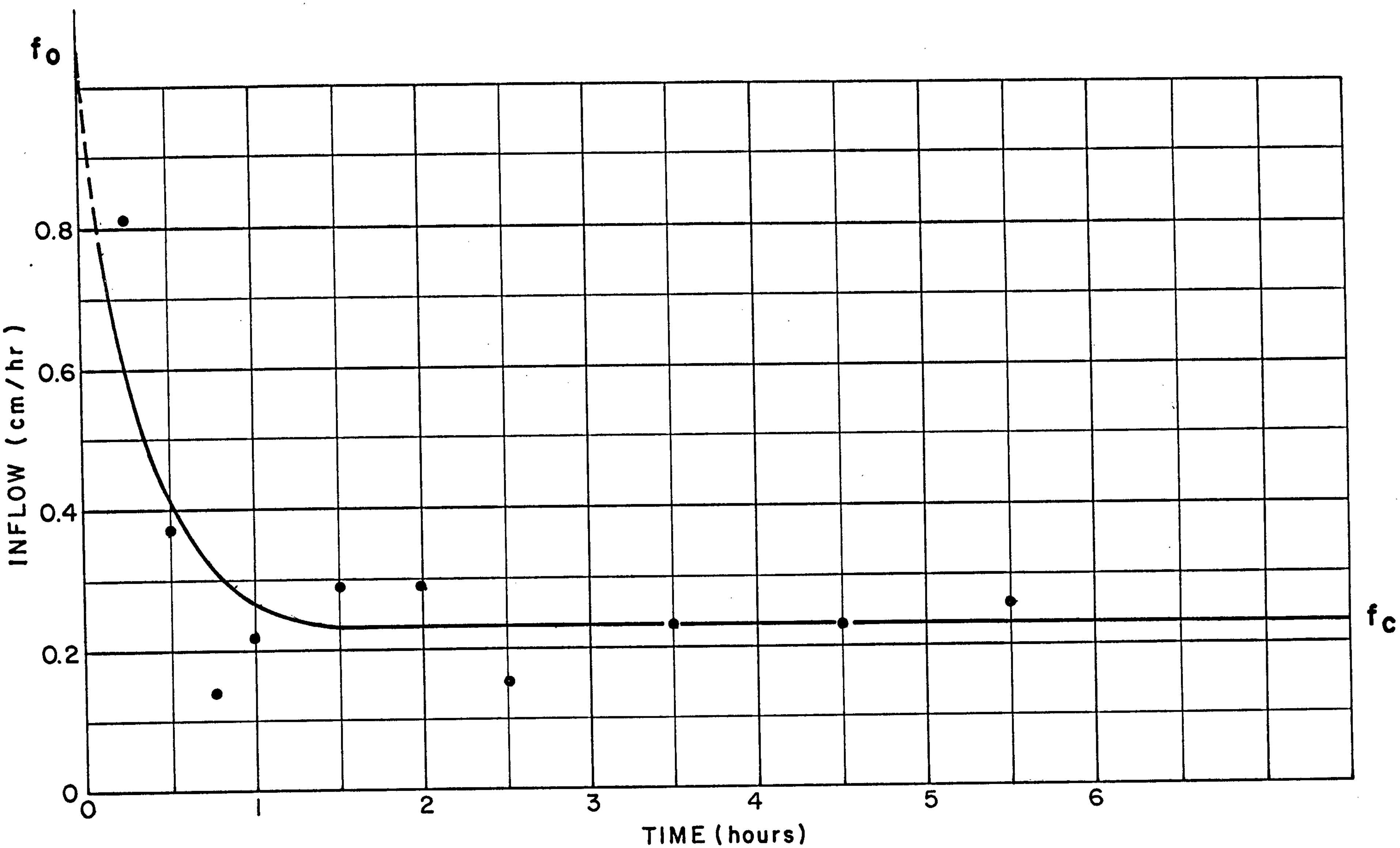
ROCKY MOUNTAIN ARSENAL DENVER, COLORADO RESOURCE CONSULTANTS, INC. – FORT COLLINS, COLORADO	Fig. 8. **INFILTRATION SITE No. 3**	**7/14/83** **7/15/83**



ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO
RESOURCE CONSULTANTS, INC. – FORT COLLINS, COLORADO

Fig. 9.
INFILTRATION SITE No.4

7/14/83

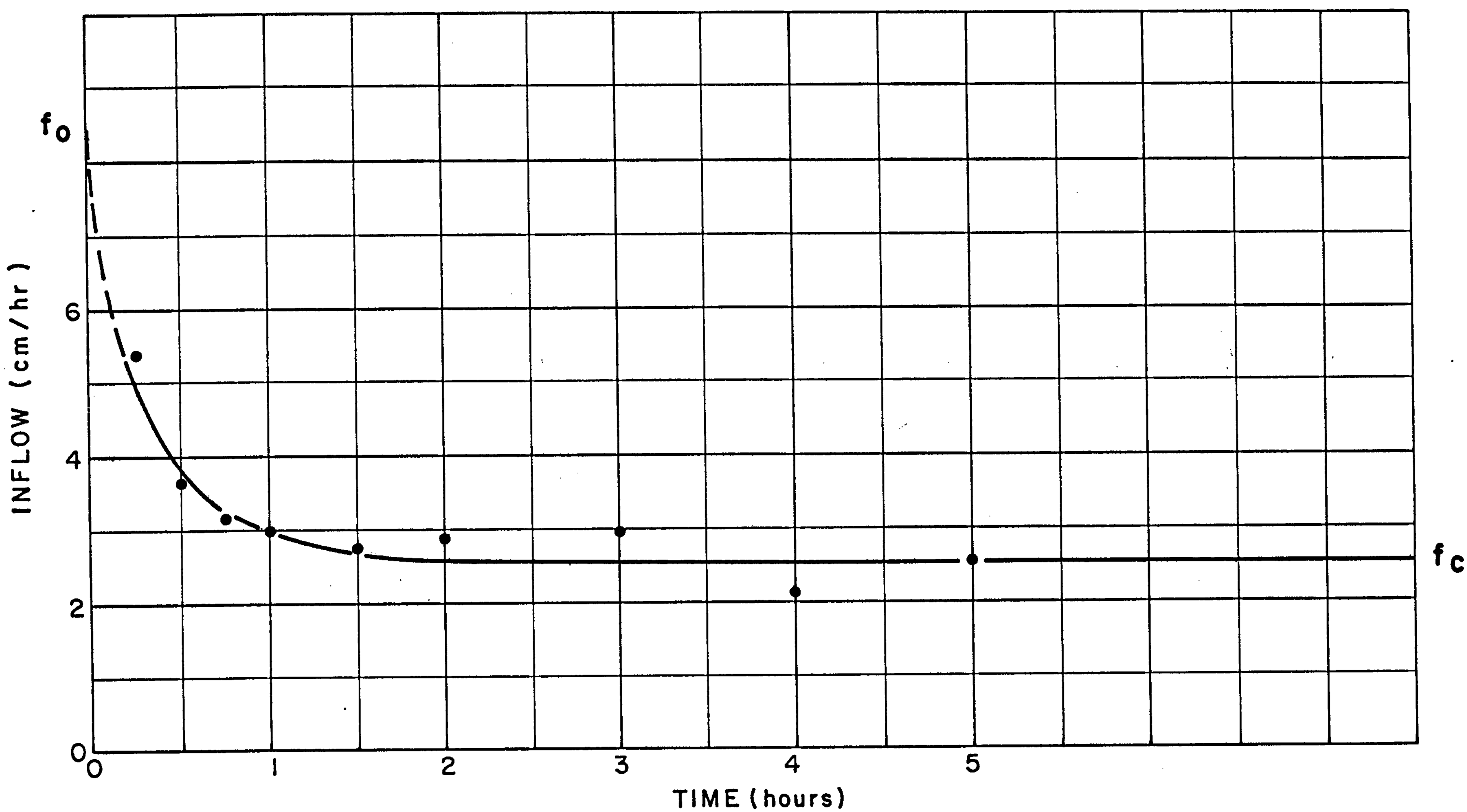


ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO

RESOURCE CONSULTANTS, INC. – FORT COLLINS, COLORADO

Fig. 10.
INFILTRATION SITE No. 5

7/14/83

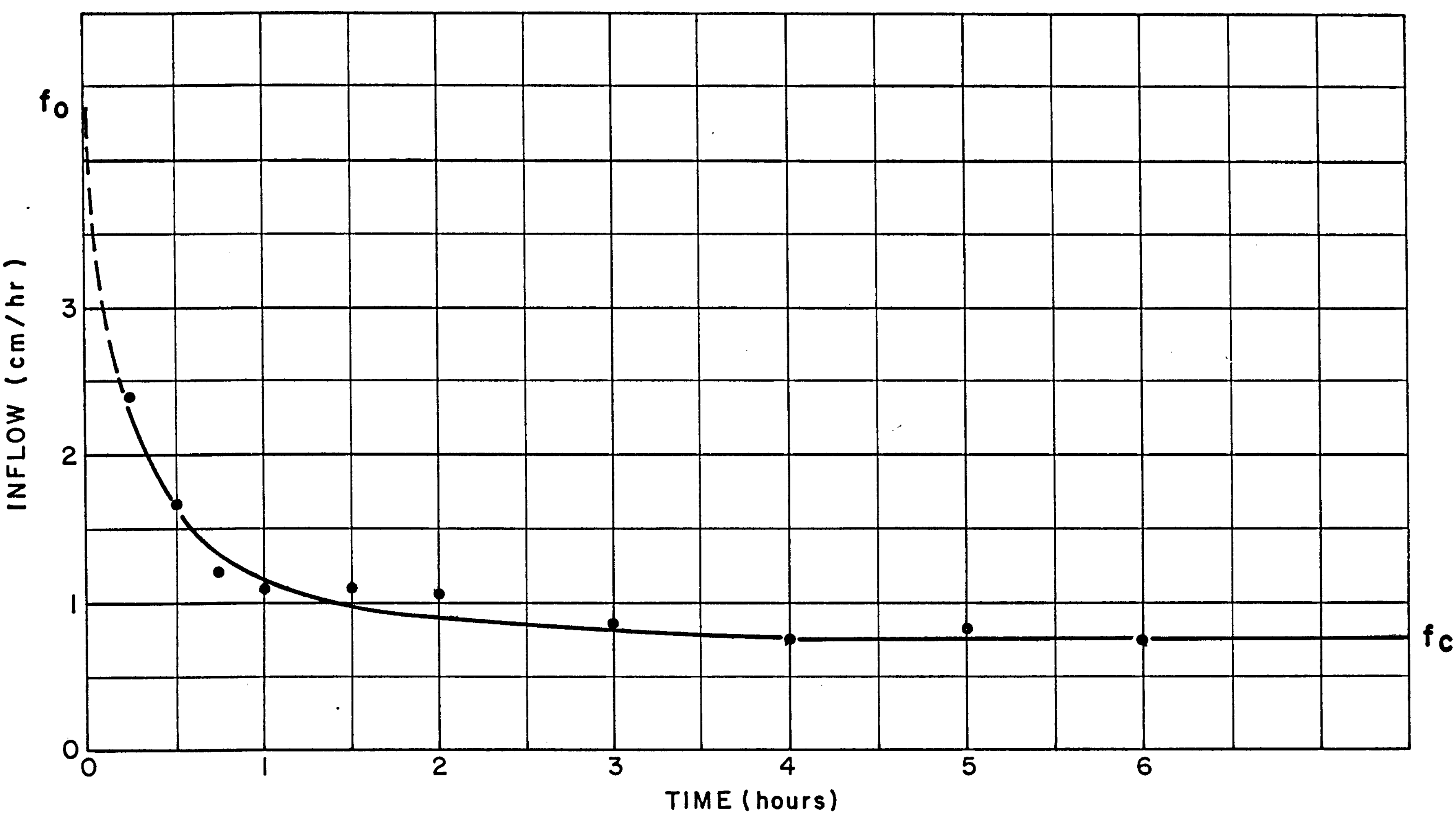


ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO

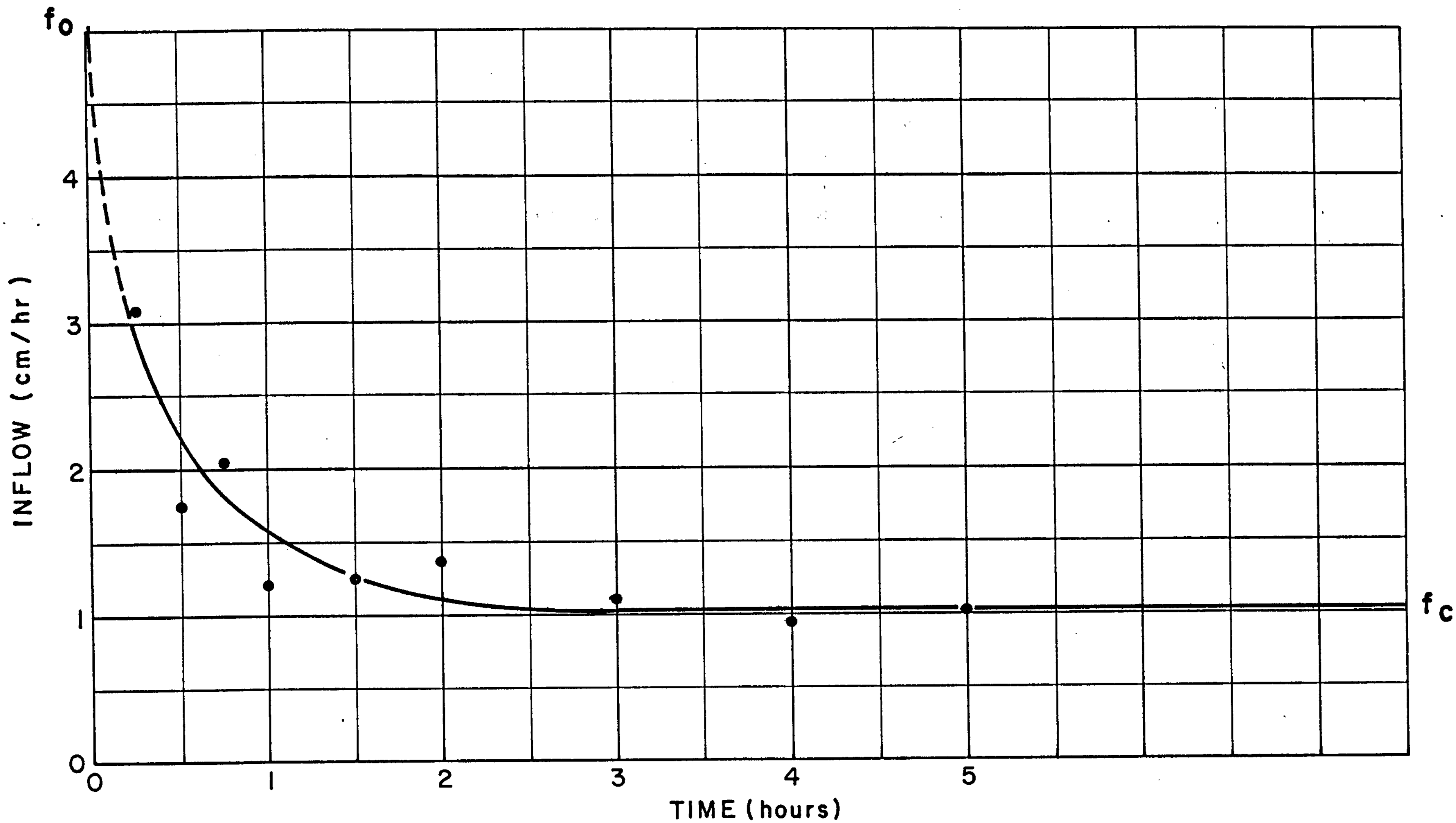
RESOURCE CONSULTANTS, INC. – FORT COLLINS, COLORADO

Fig. 11.
INFILTRATION SITE No. 6

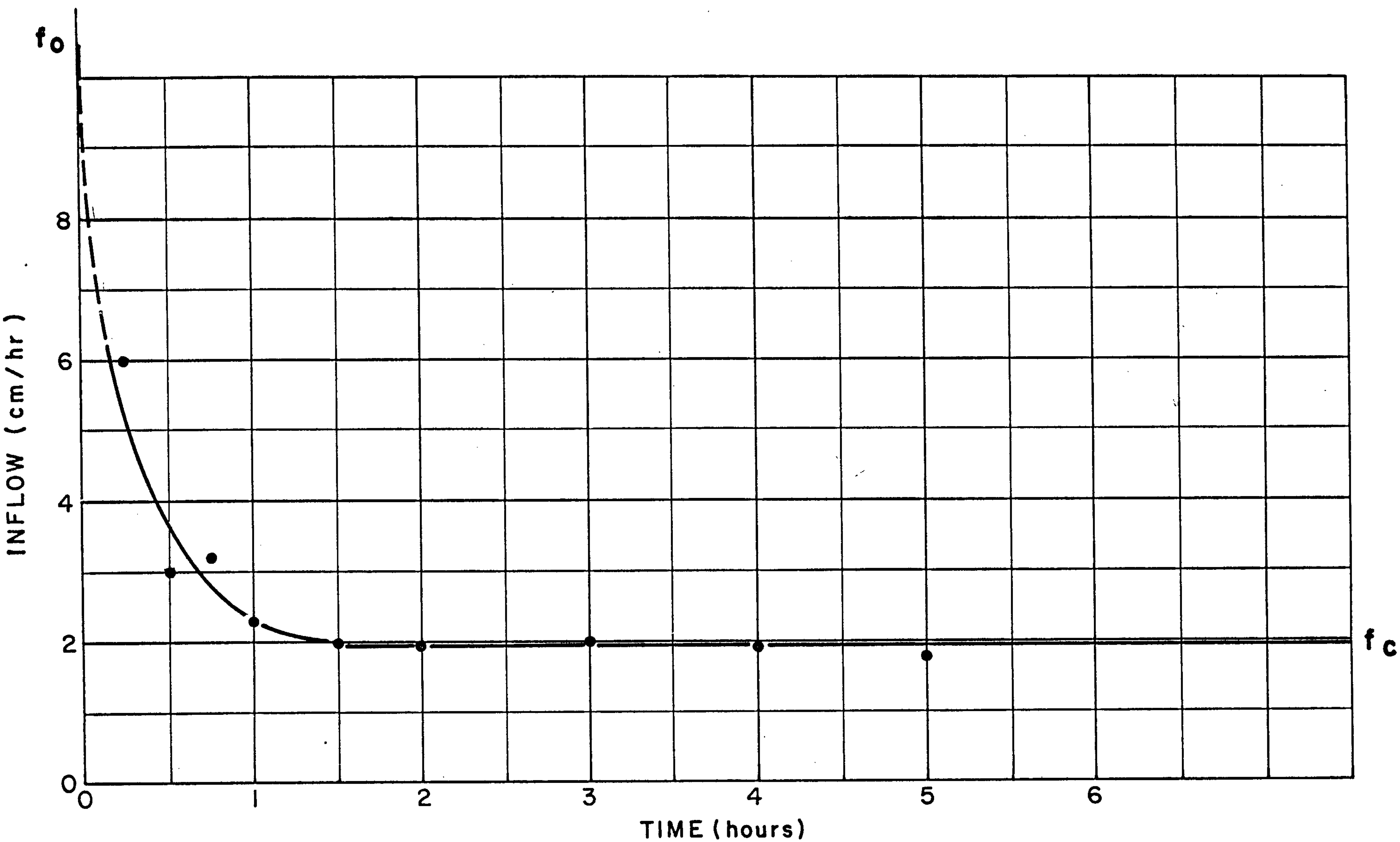
7/14/83



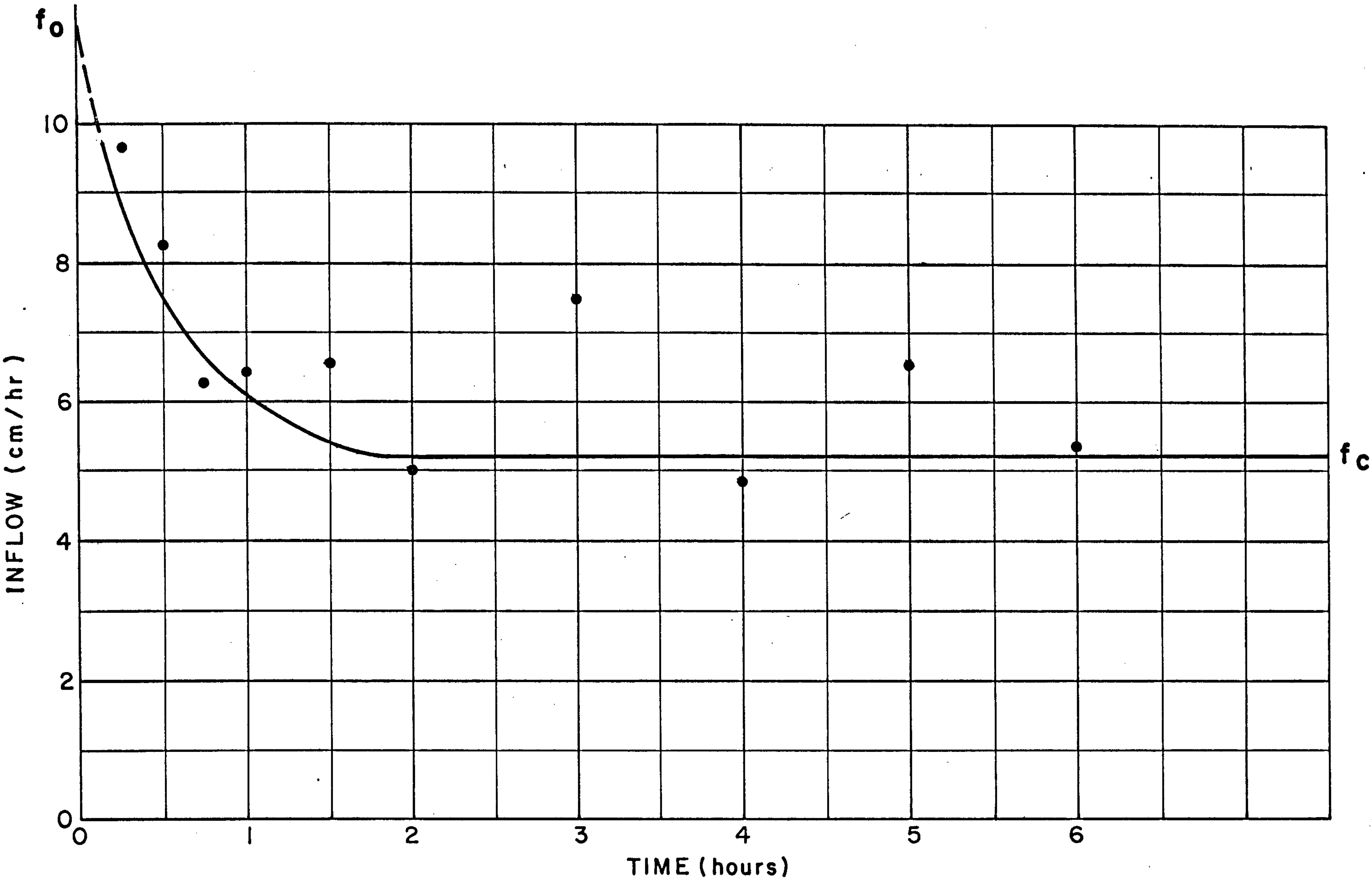
ROCKY MOUNTAIN ARSENAL DENVER, COLORADO RESOURCE CONSULTANTS, INC. – FORT COLLINS, COLORADO	Fig. 12. **INFILTRATION SITE No. 7**	**7/13/83**



ROCKY MOUNTAIN ARSENAL DENVER, COLORADO RESOURCE CONSULTANTS, INC. – FORT COLLINS, COLORADO	Fig. 13. **INFILTRATION SITE No. 8**	**7/13/83**



ROCKY MOUNTAIN ARSENAL **DENVER, COLORADO** RESOURCE CONSULTANTS, INC. – FORT COLLINS, COLORADO	Fig. 14. **INFILTRATION SITE No. 9**	**7/13/83**



ROCKY MOUNTAIN ARSENAL DENVER, COLORADO RESOURCE CONSULTANTS, INC. – FORT COLLINS, COLORADO	Fig. 15. **INFILTRATION SITE No.10**	**7/13/83**

Recommendations and Conclusions

Data in this report are based on one series of tests only. If this information is to be used for design purposes, the series should be repeated. Site #4 appears to be a difficult site for infiltration tests. It is reommended that this site be moved to a more favorable location.

Data in Table 1 indicate some very low values of infiltration rates. Any value less than about 0.1 centimeters per hour should be considered as impermeable for surface-water runoff computations.

Bibliography

American Society for Testing and Materials, 1978, Annual Book of ASTM Standards, Part 19, ASTM, 1916 Race Street, Philadelphia, PA 19103, 560 pages.

Horton, R. E., 1935, Surface Runoff Phenomena: Part I, Analysis of the Hydrograph, Horton Hydrological Laboratory Publication 101, Ann Arbor, MI, Edwards Brothers, Inc.

Johnson, A. I., 1963, A Field Method for Measurement of Infiltration, U. S. Geological Survey Water-Supply Paper 1544-F, U. S. Government Printing Office, Washington, DC, 27 pages.

USDA, Soil Conservation Service & Colo. Ag. Exper. Station, 1974, Soil Survey of Adams County, Colorado.

APPENDIX B

Numerical Data for Test Sites

ROCKY MOUNTAIN ARSENAL INFILTRATION TESTS
JULY 1983

SITE #	DATE	TIME	AREA (CM**2)	INTERVAL (MIN)	INTERVAL (HOURS)	TOTAL HOURS	VOL (ML)	INFLOW (CM/HR)
1	7/14/83	650	729.66	0	0	0	0	0 1/
		705	729.66	15	.25	.25	60	.33
		1105	729.66	240	4.00	4.25	110	.04
		1325	729.66	140	2.33	6.58	200	.12
	7/15/83	615	729.66	1010	16.83	23.42	1320	.11
		1100	729.66	285	4.75	28.17	110	.03
2	7/14/83	657	729.66	0	0	0	0	0
		712	729.66	15	.25	.25	140	.77
		1112	729.66	240	4.00	4.25	120	.04
		1332	729.66	140	2.33	6.58	130	.08
	7/15/83	630	729.66	1018	16.97	23.55	80	.01
		1105	729.66	275	4.58	28.13	1	.00
3	7/14/15	922	729.66	0	0	0	0	0
		1122	729.66	120	2.00	2.00	40	.03
	7/15/83	640	729.66	1158	19.30	21.30	560	.04
		1110	729.66	270	4.50	25.80	110	.03
4	7/14/83	916	729.66	0	0	0	0	0
		931	729.66	15	.25	.25	3810	20.89
		950	729.66	19	.32	.57	4670	20.21
		1005	729.66	15	.25	.82	5900	32.34
		1015	729.66	10	.17	.98	4500	37.00
		1025	729.66	10	.17	1.15	2610	21.46
		1035	729.66	10	.17	1.32	2590	21.30
		1045	729.66	10	.17	1.48	2260	18.58
		1055	729.66	10	.17	1.65	2440	20.06
		1125	729.66	30	.50	2.15	7410	20.31
		1155	729.66	30	.50	2.65	7750	21.24
		1235	729.66	40	.67	3.32	8180	16.82
		1315	729.66	40	.67	3.98	6730	13.84
		1345	729.66	30	.50	4.48	4260	11.68
5	7/14/83	837	729.66	0	0	0	0	0
		852	729.66	15	.25	.25	147	.81
		907	729.66	15	.25	.50	68	.37
		922	729.66	15	.25	.75	25	.14
		937	729.66	15	.25	1.00	40	.22
		1007	729.66	30	.50	1.50	105	.29
		1037	729.66	30	.50	2.00	105	.29
		1107	729.66	30	.50	2.50	55	.15
		1207	729.66	60	1.00	3.50	170	.23
		1307	729.66	60	1.00	4.50	170	.23
		1407	729.66	60	1.00	5.50	190	.26

1/ Zero indicates "no data."

ROCKY MOUNTAIN ARSENAL INFILTRATION TESTS JULY 1983

SITE #	DATE	TIME	AREA (CM**2)	INTERVAL (MIN)	INTERVAL (HOURS)	TOTAL HOURS	VOL (ML)	INFLOW (CM/HR)
6	7/14/83	900	729.66	0	0	0	0	0 1/
		915	729.66	15	.25	.25	975	5.34
		930	729.66	15	.25	.50	665	3.65
		945	729.66	15	.25	.75	575	3.15
		1000	729.66	15	.25	1.00	545	2.99
		1030	729.66	30	.50	1.50	1000	2.74
		1100	729.66	30	.50	2.00	1055	2.89
		1200	729.66	60	1.00	3.00	2170	2.97
		1300	729.66	60	1.00	4.00	1545	2.12
		1400	729.66	60	1.00	5.00	1870	2.56
7	7/13/83	1211	729.66	0	0	0	0	0
		1226	729.66	15	.25	.25	438	2.40
		1241	729.66	15	.25	.50	304	1.67
		1256	729.66	15	.25	.75	219	1.20
		1311	729.66	15	.25	1.00	201	1.10
		1341	729.66	30	.50	1.50	393	1.08
		1411	729.66	30	.50	2.00	384	1.05
		1511	729.66	60	1.00	3.00	624	.86
		1611	729.66	60	1.00	4.00	560	.77
		1711	729.66	60	1.00	5.00	600	.82
		1811	729.66	60	1.00	6.00	540	.74
8	7/13/83	1350	729.66	0	0	0	0	0
		1405	729.66	15	.25	.25	560	3.07
		1420	729.66	15	.25	.50	320	1.75
		1435	729.66	15	.25	.75	370	2.03
		1450	729.66	15	.25	1.00	220	1.21
		1520	729.66	30	.50	1.50	460	1.26
		1550	729.66	30	.50	2.00	500	1.37
		1650	729.66	60	1.00	3.00	820	1.12
		1750	729.66	60	1.00	4.00	700	.96
		1850	729.66	60	1.00	5.00	750	1.03
9	7/13/83	1324	729.66	0	0	0	0	0
		1339	729.66	15	.25	.25	1092	5.99
		1354	729.66	15	.25	.50	459	2.52
		1409	729.66	15	.25	.75	589	3.23
		1424	729.66	15	.25	1.00	424	2.32
		1454	729.66	30	.50	1.50	716	1.96
		1524	729.66	30	.50	2.00	713	1.95
		1624	729.66	60	1.00	3.00	1452	1.99
		1724	729.66	60	1.00	4.00	1410	1.93
		1824	729.66	60	1.00	5.00	1310	1.80
10	7/13/83	1230	729.66	0	0	0	0	0
		1245	729.66	15	.25	.25	1760	9.65
		1300	729.66	15	.25	.50	1510	8.28
		1315	729.66	15	.25	.75	1140	6.25
		1330	729.66	15	.25	1.00	1170	6.41
		1400	729.66	30	.50	1.50	2390	6.55
		1430	729.66	30	.50	2.00	1820	4.99
		1530	729.66	60	1.00	3.00	5460	7.48
		1645	729.66	75	1.25	4.25	4420	4.85
		1730	729.66	45	.75	5.00	3560	6.51
		1830	729.66	60	1.00	6.00	3900	5.34

1/ Zero indicates "no data."